Auxiliary Channel Characterization using ANN

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on behalf of

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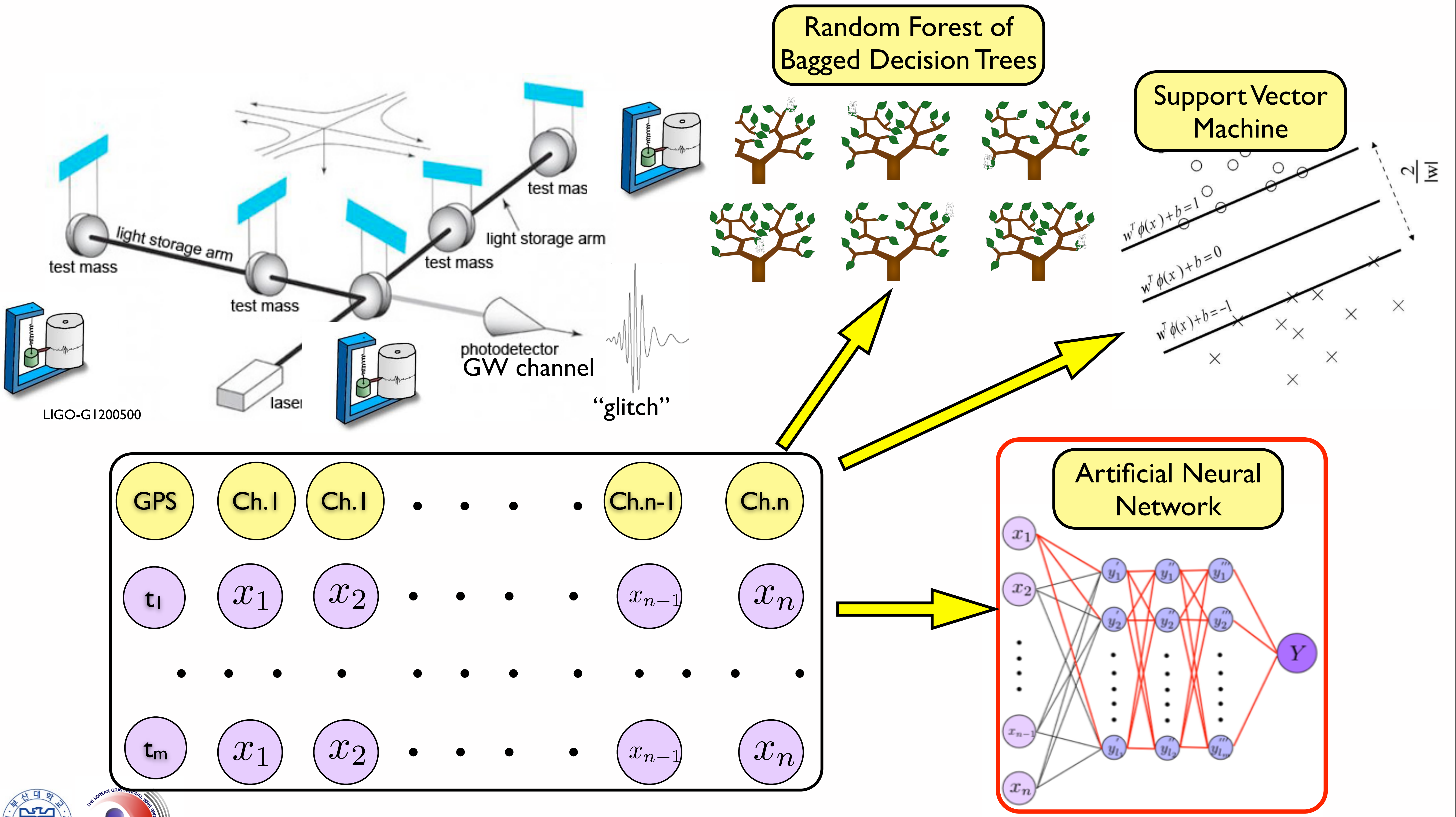
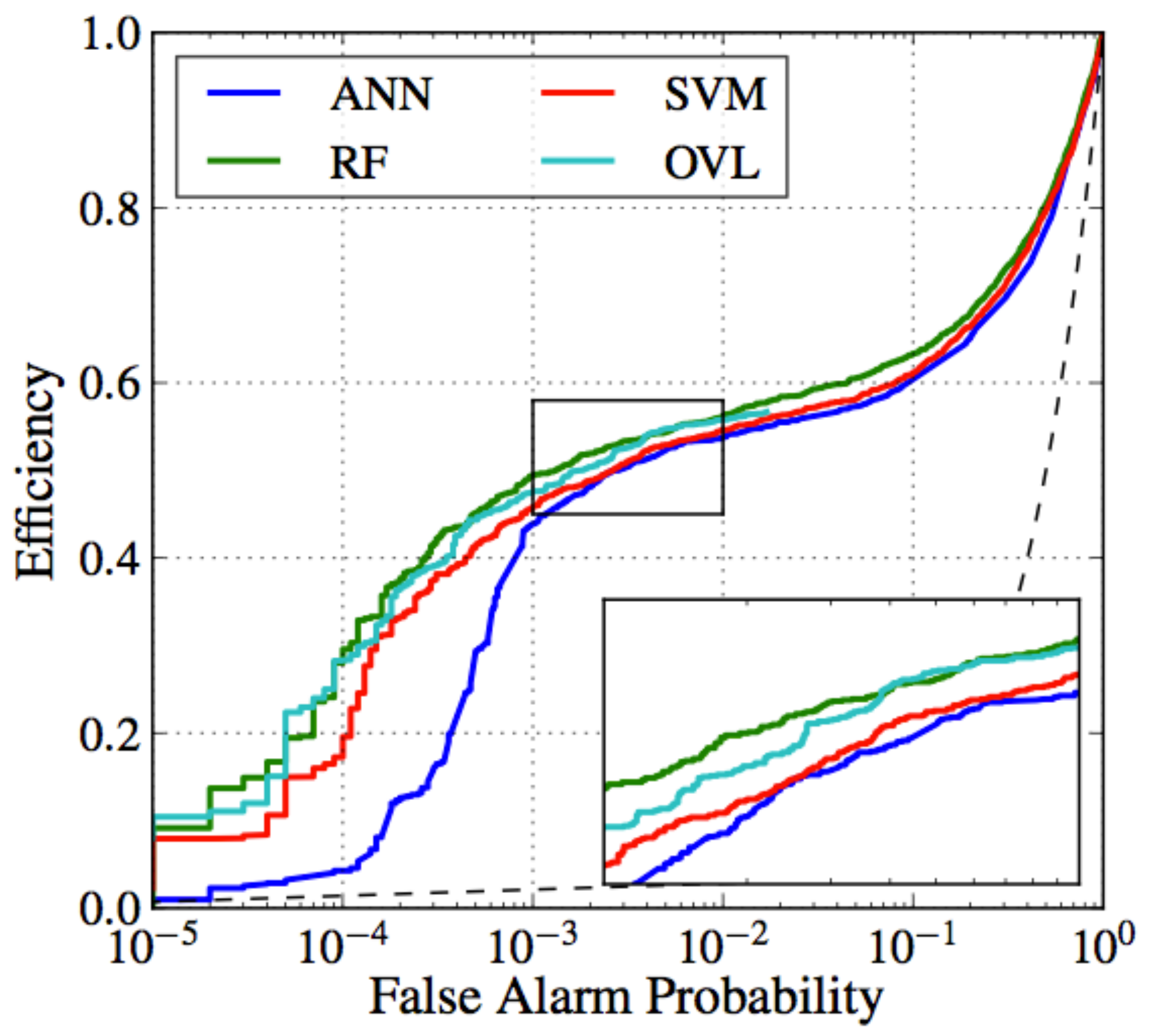
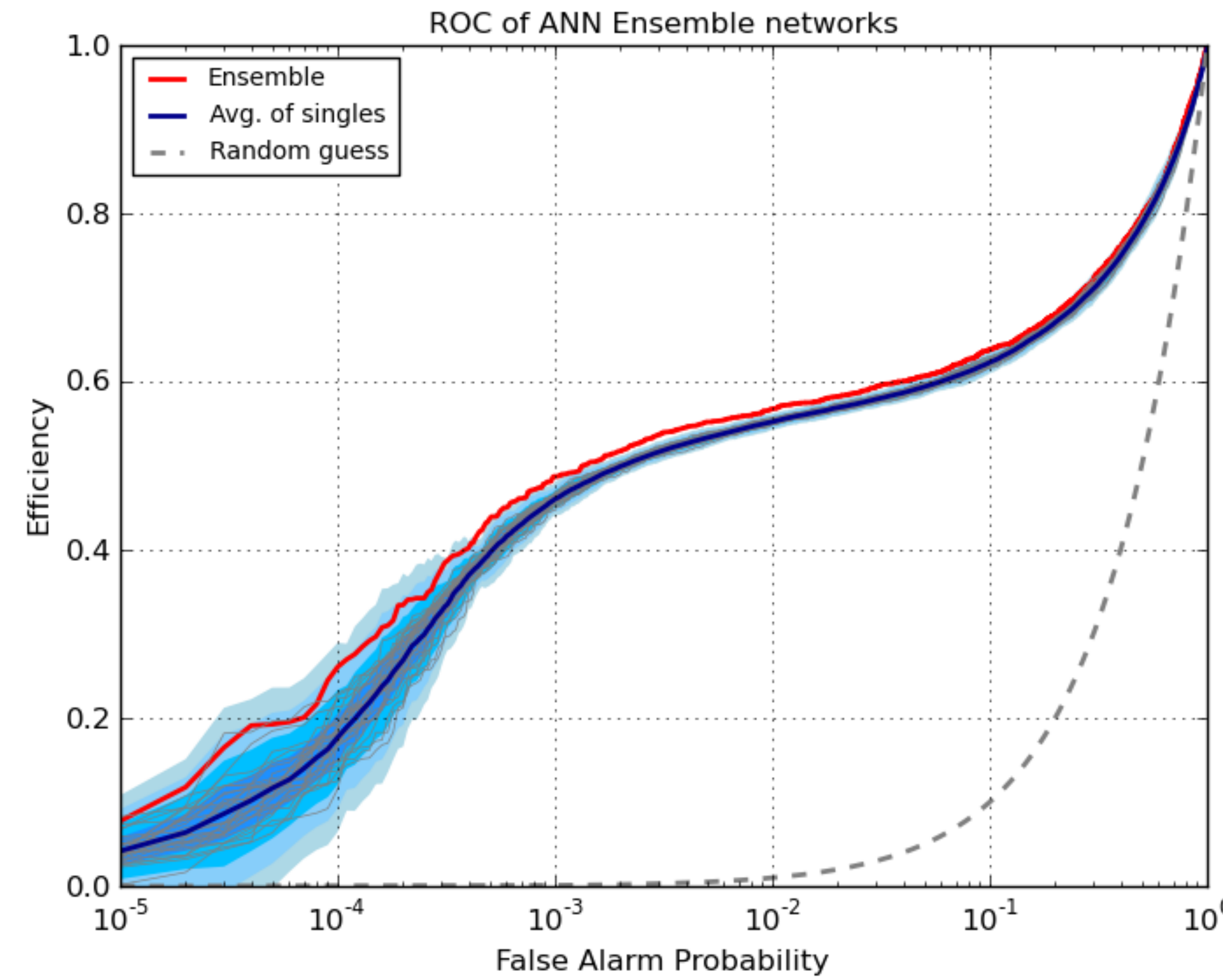
Auxiliary ch. - Multi-Variate Classifiers



Application of MLA to Glitch Identification

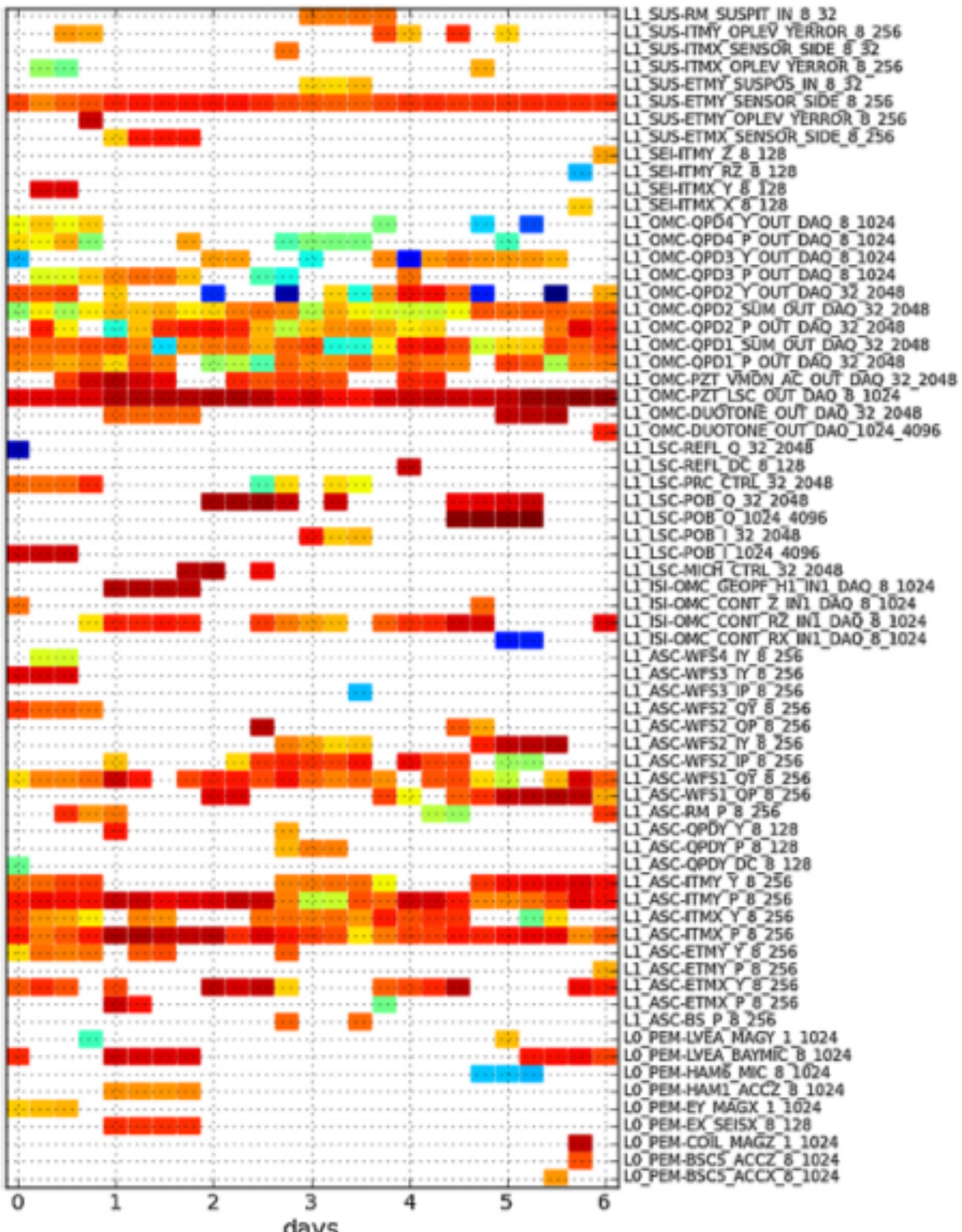


R. Biswas, et al., Phys. Rev. D 88, 062003, 2013



performance improvement of ANN

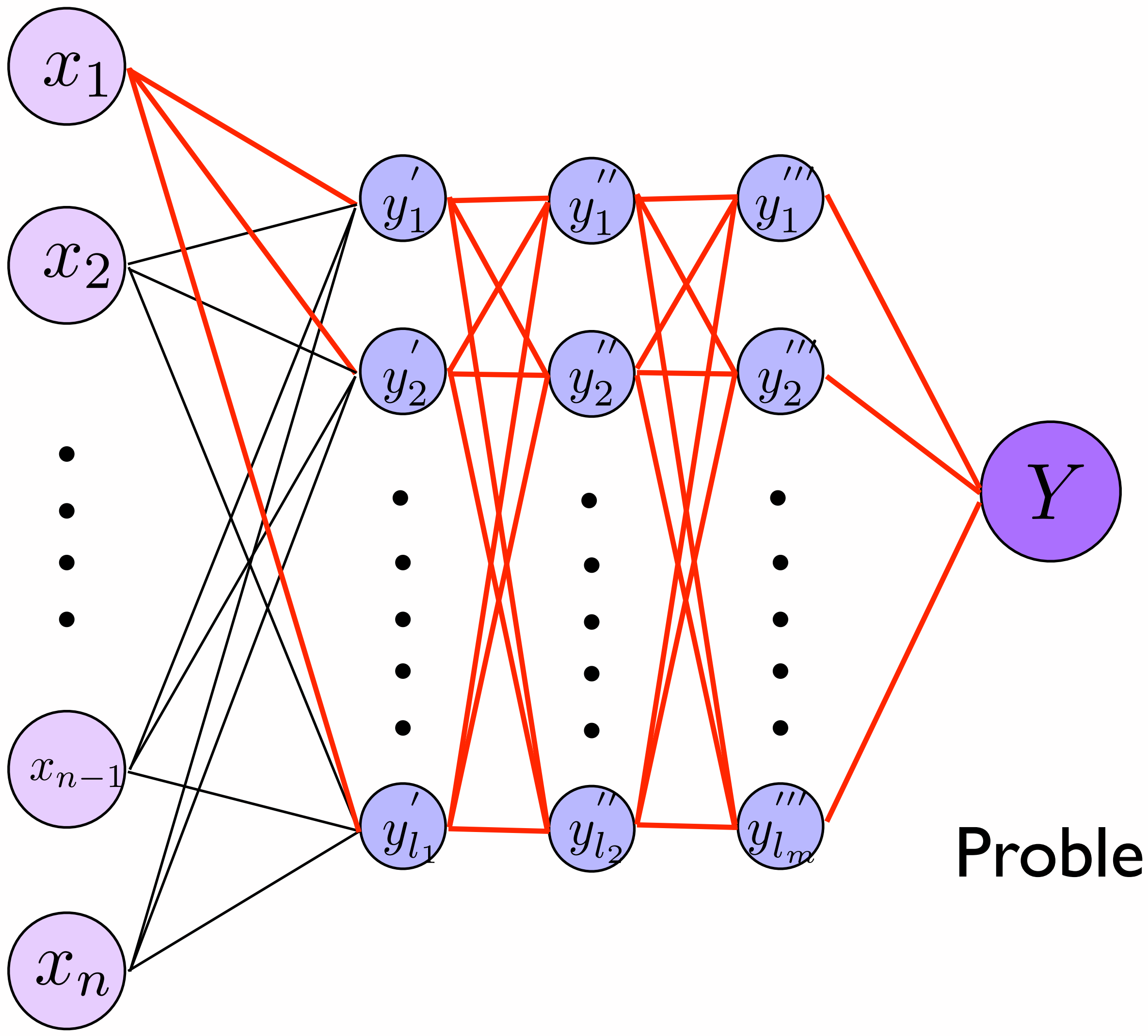
Which Aux. channels are responsible for Glitches ?



Channel Relative performance by OVL (Ordered-Veto List)

R. Essick, et al, Class. Quantum. Gav. 30, 155010 (2013)

Responsible Features in ANN

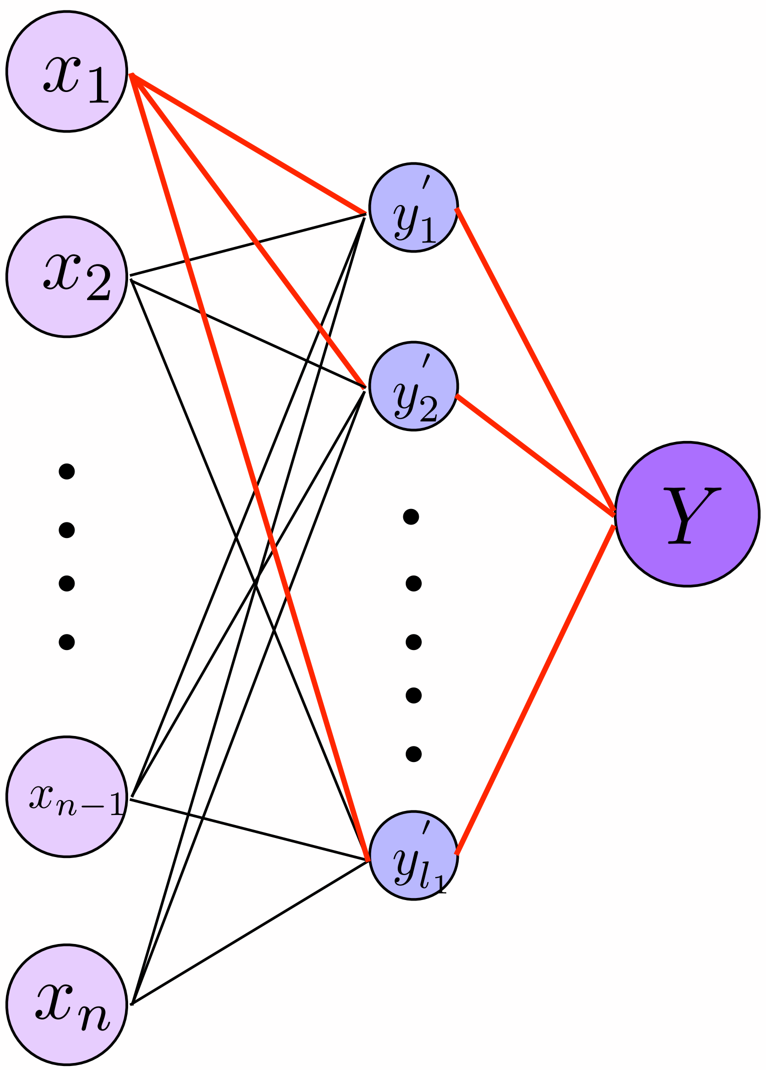


Conventional method in ANN

$$S(x_i) = \Sigma_M |w_{il_1} w_{l_1 l_2} ... w_{l_M o}|$$

Problem : No way to apply evaluation data !!

Responsible Features in ANN



Partial differentiation w.r.t feature x_i

$$\frac{\partial Y}{\partial x_i} = \frac{\partial f^o(X)}{\partial X} \Sigma_j \frac{\partial f^h(X_j)}{\partial X_j} w_{ij} w_{jo}$$

Response value w.r.t x_i defined by

$$S(x_i) = \Sigma_j \frac{\partial f^h(X_j)}{\partial X_j} w_{ij} w_{jo}$$

Response Distance Ratio

Response Vector

$$\vec{S} = (S(x_i), S(x_{i+1}), ..., S(x_{i+m}))$$

Response Distance

$$RD = \exp(-|\vec{S} - \vec{S_{t,g}}|/|\vec{S} - \vec{S_{t,c}}|)$$

Response Distance Ratio

$$RDR(\text{ch.}) = \frac{RD_{\text{ch.}}}{RD_{\text{trig}}}$$

Comparison of OVL and ANN's Conventional method

OVL

L1_LSC-POB_Q_1024_4096
L1_OMC-PZT_LSC_OUT_DAQ_8_1024
L1_ISI-OMC_GEOPF_H2_IN1_DAQ_8_1024
L0_PEM-LVEA_SEISZ_8_128
L1_ISI-OMC_GEOPF_H1_IN1_DAQ_8_1024
L1_ASC-ITMY_P_8_256
L0_PEM-LVEA_BAYMIC_8_1024
L1_ASC-BS_P_8_256
L1_LSC-POB_Q_32_2048
L1_ASC-ITMX_P_8_256
L1_ASC-WFS1_QY_8_256
L1_SUS-ETMX_SENSOR_SIDE_8_256
L1_SUS-ETMY_SENSOR_SIDE_8_256
L0_PEM-EX_SEISX_8_128
L1_ASC-ITMY_Y_8_256
L1_OMC-QPD1_P_OUT_DAQ_32_2048
L1_ASC-WFS2_IP_8_256
L1_ASC-ETMX_Y_8_256
L1_OMC-PZT_VMON_AC_OUT_DAQ_32_2048
L1_OMC-QPD1_SUM_OUT_DAQ_32_2048
L1_ASC-WFS2_QY_8_256
L1_SUS-RM_SUSPIT_IN_8_32
L1_OMC-QPD2_Y_OUT_DAQ_32_2048
L1_OMC-QPD2_SUM_OUT_DAQ_32_2048
L1_OMC-QPD2_P_OUT_DAQ_32_2048
L1_ASC-ITMX_Y_8_256
L1_ASC-WFS2_IY_8_256
L1_OMC-QPD3_Y_OUT_DAQ_8_1024
L1_LSC-PRC_CTRL_32_2048
L1_OMC-QPD3_P_OUT_DAQ_8_1024
L0_PEM-HAM1_ACCZ_8_1024
L1_ASC-WFS1_QP_8_256
L0_PEM-EY_MAGX_1_1024
L1_OMC-QPD4_P_OUT_DAQ_8_1024
L0_PEM-LVEA_MAGY_1_1024

19 ch. matched

ANN

L1_OMC-QPD1_P_OUT_DAQ_32_2048=667289.817642
L1_OMC-QPD2_Y_OUT_DAQ_32_2048=660339.342513
L1_OMC-QPD2_P_OUT_DAQ_32_2048=648880.835468
L1_OMC-PZT_LSC_OUT_DAQ_8_1024=611644.083158
L1_OMC-QPD3_P_OUT_DAQ_8_1024=560136.453594
L1_OMC-QPD1_SUM_OUT_DAQ_32_2048=464637.187728
L1_OMC-QPD2_SUM_OUT_DAQ_32_2048=340147.925119
L1_ISI-OMC_CONT_RZ_IN1_DAQ_8_1024=321934.370699
L1_LSC-REFL_Q_32_2048=281685.246617
L1_OMC-QPD4_P_OUT_DAQ_8_1024=247231.541518
L1_OMC-QPD4_Y_OUT_DAQ_8_1024=238743.180353
L1_OMC-PZT_VMON_AC_OUT_DAQ_32_2048=213446.834119
L1_OMC-QPD3_Y_OUT_DAQ_8_1024=210633.289612
L1_ISI-OMC_GEOPF_H1_IN1_DAQ_8_1024=201769.172767
L1_ASC-WFS4_IP_8_256=186508.980033
L1_ASC-WFS3_IP_8_256=174079.131805
L1_ASC-RM_P_8_256=147316.587591
L1_LSC-POB_I_1024_4096=141248.58001
L1_LSC-PRC_CTRL_32_2048=140997.938081
L1_LSC-POB_I_32_2048=132375.465581
L0_PEM-HAM1_ACCZ_8_1024=130893.99712
L1_ASC-ETMX_P_8_256=127461.52814
L1_ASC-ETMY_P_8_256=114186.921959
L1_ISI-OMC_GEOPF_H2_IN1_DAQ_8_1024=108914.685549
L1_ASC-ITMY_P_8_256=108810.943927
L0_PEM-EY_SEISY_8_128=108150.738939
L1_ISI-OMC_GEOPF_V2_IN1_DAQ_8_1024=96507.9823112
L1_ASC-ITMX_P_8_256=91580.4862366
L1_ASC-WFS2_QP_8_256=84060.8204434
L1_ASC-WFS2_IP_8_256=75559.9162881
L1_ASC-WFS1_QP_8_256=73135.1890178
L1_OMC-DUOTONE_OUT_DAQ_1024_4096=69635.8853255
L1_SUS-ETMY_SENSOR_SIDE_8_256=69559.2061476
L1_ASC-QPDY_Y_8_128=63663.2104693
L1_SEI-ETMX_Y_8_128=61582.3383791

Comparison of OVL and ANN's RDR

OVL

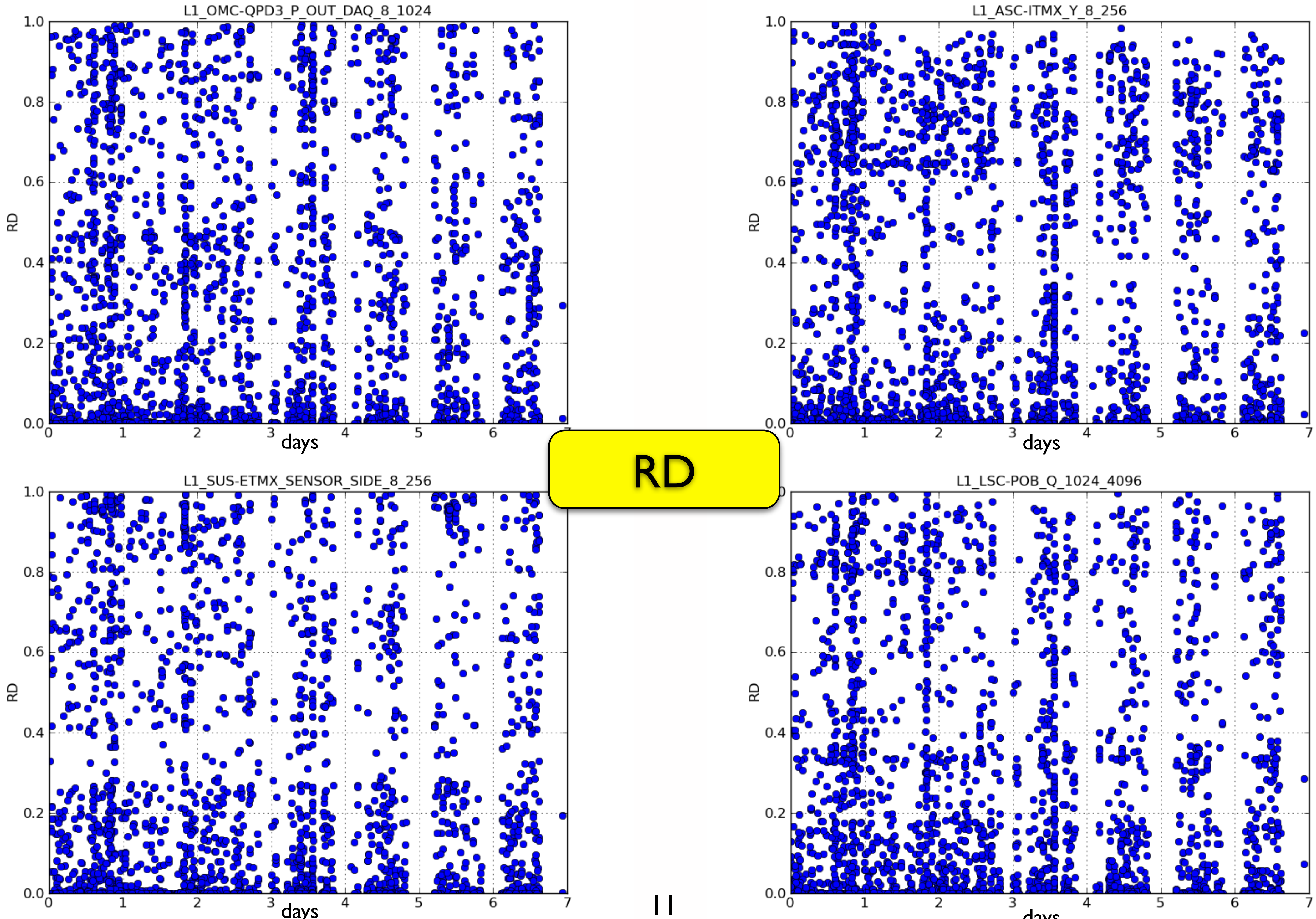
L1_LSC-POB_Q_1024_4096 o
L1_OMC-PZT_LSC_OUT_DAQ_8_1024
L1_ISI-OMC_GEOPF_H2_IN1_DAQ_8_1024 x
L0_PEM-LVEA_SEISZ_8_128
L1_ISI-OMC_GEOPF_H1_IN1_DAQ_8_1024 x
L1_ASC-ITMY_P_8_256
L0_PEM-LVEA_BAYMIC_8_1024
L1_ASC-BS_P_8_256
L1_LSC-POB_Q_32_2048 o
L1_ASC-ITMX_P_8_256 x
L1_ASC-WFS1_QY_8_256
L1_SUS-ETMX_SENSOR_SIDE_8_256 o
L1_SUS-ETMY_SENSOR_SIDE_8_256 x
L0_PEM-EX_SEISX_8_128
L1_ASC-ITMY_Y_8_256
L1_OMC-QPD1_P_OUT_DAQ_32_2048 x
L1_ASC-WFS2_IP_8_256 x
L1_ASC-ETMX_Y_8_256
L1_OMC-PZT_VMON_AC_OUT_DAQ_32_2048
L1_OMC-QPD1_SUM_OUT_DAQ_32_2048 x
L1_ASC-WFS2_QY_8_256 o
L1_SUS-RM_SUSPIT_IN_8_32
L1_OMC-QPD2_Y_OUT_DAQ_32_2048 x
L1_OMC-QPD2_SUM_OUT_DAQ_32_2048 x
L1_OMC-QPD2_P_OUT_DAQ_32_2048 x
L1_ASC-ITMX_Y_8_256 o
L1_ASC-WFS2_IY_8_256
L1_OMC-QPD3_Y_OUT_DAQ_8_1024
L1_LSC-PRC_CTRL_32_2048 x
L1_OMC-QPD3_P_OUT_DAQ_8_1024
L0_PEM-HAM1_ACCZ_8_1024 x
L1_ASC-WFS1_QP_8_256 x
L0_PEM-EY_MAGX_1_1024 o
L1_OMC-QPD4_P_OUT_DAQ_8_1024
L0_PEM-LVEA_MAGY_1_1024

ANN

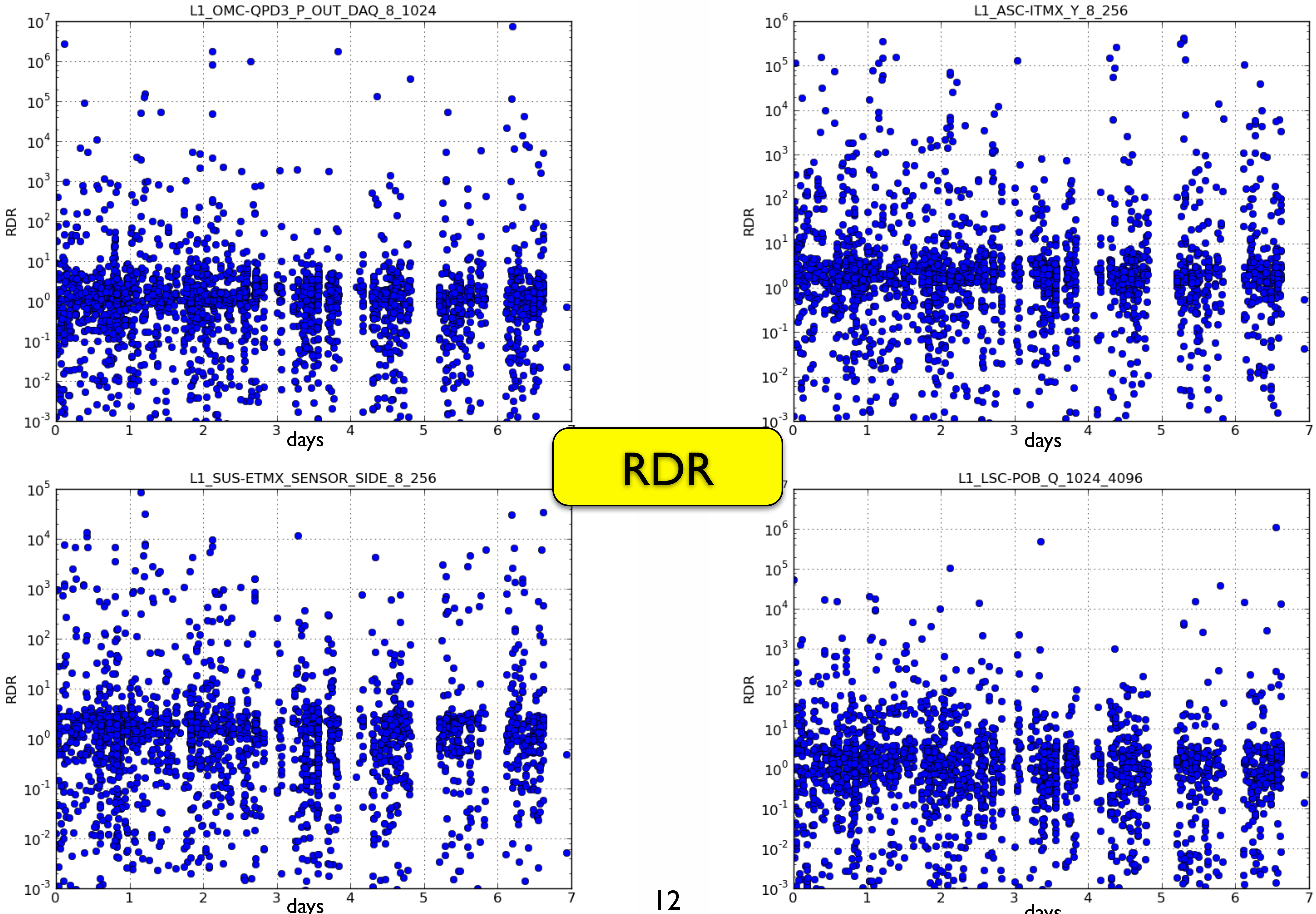
L1_SEI-ITMY_RZ_8_128 0.740016983743 2.01157471966
L0_PEM-HAM6_ACCZ_8_1024 0.736632432769 2.00237455625
L1_ASC-BS_Y_8_256 0.726270494539 1.97420788785
L1_OMC-QPD3_P_OUT_DAQ_8_1024 0.711771641732 1.93479591973
L1_ASC-WFS2_QP_8_256 0.703548731125 1.91244373125
L1_ASC-WFS3_IY_8_256 0.697835505794 1.89691357465
L1_ASC-ITMX_Y_8_256 0.695094992482 1.88946408712
L1_OMC-PZT_VMON_AC_OUT_DAQ_32_2048 0.693260130957 1.884476416
L1_SUS-ETMX_OPLEV_PERROR_8_256 0.692061222468 1.88121744522
L1_SUS-ETMX_SENSOR_SIDE_8_256 0.689621175732 1.87458471051
L1_OMC-QPD4_Y_OUT_DAQ_8_1024 0.682585926804 1.85546092119
L1_SUS-ITMX_SENSOR_SIDE_8_32 0.679554226783 1.84721990612
L1_SEI-ITMY_Y_8_128 0.679095171411 1.84597206424
L1_SEI-MC1_X_8_128 0.677927424003 1.84279779768
L1_ISI-OMC_CONT_Z_IN1_DAQ_8_1024 0.67749275416 1.8416162425
L1_SUS-ITMX_OPLEV_YERROR_8_256 0.677247149159 1.84094861894
L1_SUS-RM_SENSOR_SIDE_8_32 0.675818980077 1.83706645287
L1_LSC-POB_Q_1024_4096 0.664410680837 1.80605548035
L1_SUS-ITMY_OPLEV_PERROR_8_256 0.662599911454 1.80113329885
L1_OMC-PZT_LSC_OUT_DAQ_8_1024 0.661603540287 1.79842488121
L1_ISI-OMC_CONT_X_IN1_DAQ_8_1024 0.661086950477 1.79702064451
L1_ASC-ITMY_P_8_256 0.659894466762 1.7937791377
L1_OMC-QPD4_P_OUT_DAQ_8_1024 0.658701874793 1.79053733662
L1_ASC-QPDY_Y_8_128 0.655030878631 1.78055853446
L0_PEM-HAM6_ACCX_8_1024 0.6536031036 1.77667743954
L1_LSC-POB_Q_32_2048 0.649963887558 1.7667850247
L0_PEM-PSL1_MIC_8_1024 0.648241657141 1.76210351706
L0_PEM-EY_MAGX_1_1024 0.647291194201 1.75951989092
L1_OMC-QPD3_Y_OUT_DAQ_8_1024 0.646577948411 1.75758108785
L0_PEM-BSC4_ACCX_8_1024 0.645943914263 1.75585760434
L1_ASC-WFS2_QY_8_256 0.645143663842 1.75368229817
L1_LSC-REFL_Q_32_2048 0.642584914562 1.74672689649
L0_PEM-LVEA_MAGZ_1_1024 0.641143275716 1.74280811582
L0_PEM-HAM6_MIC_8_1024 0.6325056834 1.71932870558
L0_PEM-BSC5_ACCZ_8_1024 0.63033887668 1.71343871425

11 ch. matched

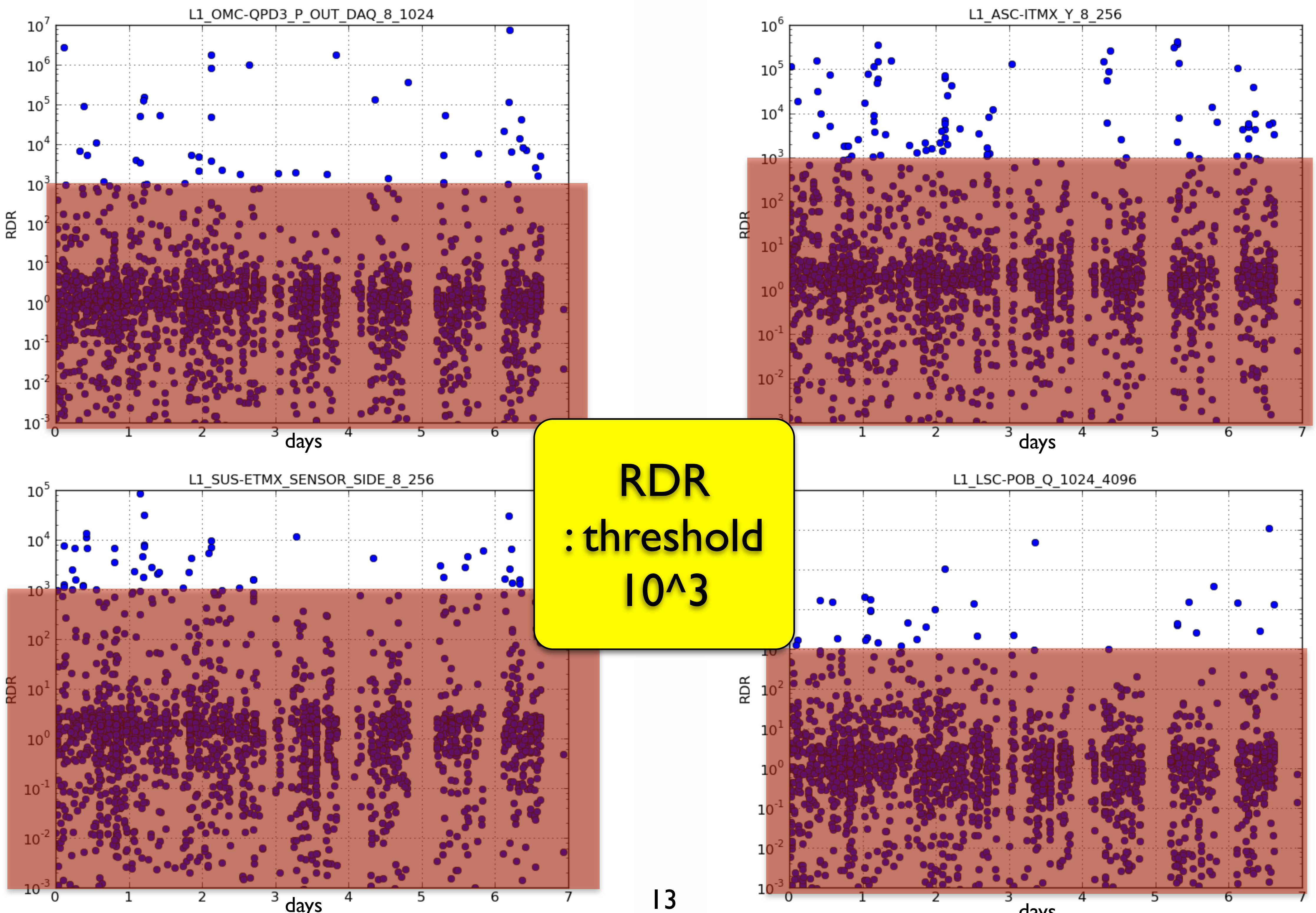
Aux. Channels Relative Response Trends



Aux. Channels Relative Response Trends



Aux. Channels Relative Response Trends



Summary and Future plans

1. To figure out which channels are responsible for glitches, Response Vector and Response Distance Ratio (RDR) are defined.
2. In RDR trend plots, auxiliary channels' relative response for glitch appearance may be dependent on RDR threshold.
    - Find appropriate RDR threshold
3. High RDR channels don't seem to match to OVL's veto channels.
    - High RDR channels may indicate different sources of glitches.
4. Compare RDR trend plots to conventional monitoring tools (OVL, Hveto etc.) channel by channel
5. Implementation into low-latency DQ pipeline (iDQ)

Thank you for your attention !!